ENGR 240 Science of Materials

Homework 6 – Electrical Properties, Part 1

14 points

1. [1 point] Callister Problem 19.3 – conductivity/resistivity calculations.

2. [2 points] The Travltoast toaster by Empire (1970's) was designed to work with the 12 V adapter in your car – great for breakfast on the go! The heating element wires in the Travltoast are made from a material called Nichrome, which is a common electrical resistance alloy that has a composition of approximately 80 wt.% nickel and 20 wt.% chromium. The Nichrome heating wires are 0.5 mm diameter Nichrome wire (σ for Nichrome is 9.3×10^5 $(\Omega \cdot m)^{-1}$), and the total length of the heating element wires is 4 meters.

   a. Calculate the current flow through the wires.
   b. The life of toaster heating elements increases if they are made from larger diameter wire. If the diameter of the heating element wires were increased from 0.5 mm to 2 mm, what would happen to the resistivity of the Nichrome wires?

3. [3 points] Draw a schematic energy band diagram for (i) nickel, (ii) aluminum oxide, and (iii) germanium. Be sure to label all the important features on your diagrams.

4. [2 points] Callister Problem 19.13 – electron mobility.

5. [4 points] At room temperature, copper-tungsten alloys of any composition will exist as two separate solid phases. Molybdenum and tungsten, on the other hand, are completely soluble in the solid state at room temperature (they form a single phase solid). The conductivity values of tungsten, molybdenum, and copper are as follows:

Copper:	$\sigma = 5.8 \times 10^7$ $(\Omega\text{-m})^{-1}$
Tungsten:	$\sigma = 1.9 \times 10^7$ $(\Omega\text{-m})^{-1}$
Molybdenum:	$\sigma = 1.9 \times 10^7$ $(\Omega\text{-m})^{-1}$

   a. Use Excel or another computer graphing program to plot the conductivity of tungsten-copper alloys as a function of volume percent tungsten. Compute and plot conductivity values at every 5 volume % tungsten increment.
   b. On the same graph, schematically plot the conductivity of single-phase molybdenum-tungsten alloys as a function of volume percent tungsten.

6. [2 points] Using data in Table 19.2, estimate the conductivity of InSb at a temperature of 200 °C.